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COMPARATIVE FATIGUE TESTS OF RIVETED JOINTS OF ALCLAD 24S-T

ALCLAD 24S-T81, ALCLAD 24S-RT, ALCLAD 24S-T86

AND ALCLAD 75S-T SHEET

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WASHINGTON

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RESTRICTED BULLETIN

COMPARATIVE FATIGUE TESTS OF RIVETED JOINTS OF ALCLAD 24S-T ALCLAD 24S-T81, ALCLAD 24S-RT, ALCLAD 24S-T86 AND ALCLAD 75S-T SHEET

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During the latter part of 1943, a comprehensive series of tests was undertaken by the Aluminum Research Laboratories to determine the fatigue strength of various types of riveted and spot-welded joints in the aluminum alloys of current interest in aircraft design. This progress report presents the results obtained to date on the riveted joints of this series.

All of the sheet was nominally 0.064 inch thick with 2½-percent alclad coating on each side.[1] The naturally and artificially aged 24S samples were obtained from the same original lots of material. Table I gives the tensile properties. The values in all cases are within a few percent of those considered typical for these alloys in the form of sheet.

The rivets were all 3/16-inch diameter 24S-T, with brazier manufactured heads and flat-driven heads, the flat-driven heads having a diameter equal to about 1½ times the shank diameter. The rivets were heat-treated, quenched, refrigerated, and driven immediately upon removal from the refrigerant. All rivets were aged at least 4 days at room temperature before being tested. None of the rivets was artificially aged.

Figure 1 shows the panel form in which the fatigue specimens were fabricated. Each panel provided 16 specimens of the type shown in figure 2, or enough for four fatigue tests. Specimens for three static tests were prepared in the form indicated in figure 3.

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[1] Commercial alclad 75S-T sheet now has a nominal coating thickness of 4 percent.

The tests were made in machines of the rotating-beam type in which specimens are subjected to complete reversal of load tending to shear the rivets. These machines, shown in figures 4 and 5, were designed and built at the Laboratories in 1942. They operate at 1750 rpm.

Table II gives a summary of the average joint strengths obtained in both the static and fatigue tests. These average strengths were based on static tensile tests made on three specimens of each material and on fatigue tests made on four specimens at each load and for each material. Rivet failures were obtained in all the static tests at shear stresses ranging from 43,400 psi to 45,100 psi. The latter values are 6 to 10 percent higher than the Army-Navy allowable shear design stress for 24S-T rivets (table 5-14, ANC-5, Amendment-1, 10-22-43). Sheet failures were obtained in practically all the fatigue tests, as expected from the proportions of specimen used.

Figures 6, 7, and 8 show the S-N curves corresponding to the fatigue data summarized in table II. Figure 9 shows the curves for all alloys on one sheet to facilitate comparisons. Although the curves for the different materials are not parallel and consequently do not maintain the same relative position throughout the entire load range investigated, it is quite evident that the naturally aged 24S-T and 24S-RT specimens were superior to the artificially aged 24S-T81 and 24S-T86 specimens from the standpoint of fatigue strength. The 75S-T specimens were for the most part intermediate between these two groups. The following table, based on the curves in figure 9, shows the relative fatigue strengths for different numbers of cycles in terms of the values for 24S-T rated at 100:

Alloy	Relative fatigue strengths (percent)			
	Number of cycles			
	200,000	1,000,000	10,000,000	100,000,000
Alclad 24S-T	100	100	100	100
Alclad 24S-RT	100	107	93	62
Alclad 75S-T	96	92	74	64
Alclad 24S-T81	92	86	58	52
Alclad 24S-T86	91	84	63	64

Aluminum Research Laboratories,
Aluminum Company of America,
New Kensington, Pa., March 2, 1945.

TABLE I

TENSILE PROPERTIES OF 0.064-INCH ALCLAD SHEET

J. O. NO. 12-76

Alloy	Sample number[1]	Yield strength (0.2 percent offset) (psi)	Ultimate strength (psi)	Elongation in 2 inches (percent)
Alclad 24S-T	67793-1-W	51,700	68,800	20.3
	-X	44,400	66,800	19.0
Alclad 24S-T81	67793-2-W	62,500	68,900	6.5
	-X	60,200	67,200	6.3
Alclad 24S-RT	62968-1-W	60,900	71,900	15.5
	-X	54,100	70,000	14.0
Alclad 24S-T86	62968-2-W	69,600	73,600	6.5
	-X	68,200	72,600	6.3
Alclad 75S-T	63317-W	71,200	80,400	14.0
	-X	66,800	78,800	14.0

[1] Specimen marked W - with-grain.
Specimen marked X - across-grain.

Standard tension test specimens for sheet metals used. See fig. 2 of Standard Methods of Tension Testing of Metallic Materials (E8-42), Book of A.S.T.M. Standards, pt. I, 1942, p. 899.

SUMMARY OF TEST RESULTS FOR RIVETED JOINTS

3/16-in. Diameter 24S-T Brazier Head Rivets in 1-in. Wide Lap Joints (See Footnotes)

J. O. No. 12-76

Sheet Alloy	Thickness, in.	Specimen No.	Load per Rivet, lb	Corresponding Stresses, psi			No. of Cycles	Type of Failure
				Tension	Shear	Bearing		
Alclad 24S-T	0.065	67793-1-0	1255	23 900	44 000	101 000	Static Test	Rivet
		-9	550	10 500	19 200	44 300	192 200	Sheet
		-11	525	10 000	18 300	42 300	231 500	Sheet
		-4	500	9 500	17 500	40 300	152 500	Sheet
		-12	420	8 000	14 700	33 800	337 900	Sheet
		-2	400	7 600	14 000	32 200	288 500	Sheet
		-10	350	6 600	12 200	28 200	924 100	Sheet
		-3	300	5 700	10 500	24 200	1 006 500	Sheet
		-7	240	4 600	8 400	19 300	3 999 900	Sheet
		-1	200	3 800	7 000	16 100	11 003 300	Sheet
		-8	185	3 500	6 500	14 900	100 617 500	None
		-6	170	3 200	5 900	13 700	100 526 700	None
		-5	150	2 800	5 200	12 100	100 302 900	None
Alclad 24S-T81	0.065	67793-2-0	1250	23 800	43 700	101 000	Static Test	Rivet
		-12	550	10 500	19 200	44 300	135 500	Sheet
		-11	520	9 900	18 200	41 900	200 400	Sheet
		-4	500	9 500	17 500	40 300	15 000	Rivet
		-6	490	9 300	17 100	39 500	133 000	Rivet
		-5	450	8 600	15 700	36 300	207 300	Sheet
		-3	400	7 600	14 000	32 200	350 300	Sheet
		-2	300	5 700	10 500	24 200	875 200	Sheet
		-1	200	3 800	7 000	16 100	2 459 100	Sheet
		-7	150	2 800	5 200	12 100	3 553 600	Sheet
		-8	120	2 300	4 200	9 700	13 890 700	Sheet
		-9	110	2 100	3 800	8 900	9 052 500	Sheet
		-10	95	1 800	3 300	7 700	103 154 700	None
Alclad 24S-RT	0.066	62968-1-0	1250	23 400	43 700	99 000	Static Test	Rivet
		-14	550	10 300	19 200	43 600	88 000	Rivet
		-16	550	10 300	19 200	43 600	178 500	Sheet
		-13	498	9 300	17 400	39 500	211 900	Sheet
		-12	400	7 500	14 000	31 800	522 400	Sheet
		-5	350	6 600	12 200	27 800	920 700	Sheet
		-3	300	5 600	10 500	23 800	1 104 000	Sheet
		-2	250	4 700	8 700	19 800	5 300 900	Sheet
		-15	225	4 200	7 900	17 900	17 918 100	Sheet
		-1	200	3 700	7 000	15 900	8 114 800	Sheet
		-4	175	3 300	6 100	13 900	28 973 900	Sheet
		-7	160	3 000	5 600	12 700	10 678 300	Sheet
		-8	140	2 600	4 900	11 100	40 962 100	Sheet
		-9	130	2 400	4 500	10 300	27 592 100	Sheet
		-10	120	2 200	4 200	9 500	69 060 600	Sheet
		-11	110	2 100	3 800	8 700	109 883 400	None
Alclad 24S-T86	0.066	62968-2-0	1250	23 400	43 700	99 000	Static Test	Rivet
		-15	549	10 300	19 200	43 600	115 600	Rivet
		-14	500	9 400	17 500	39 700	144 400	Sheet
		-13	400	7 500	14 000	31 800	312 600	Sheet
		-8	350	6 600	12 200	27 800	593 300	Sheet
		-1	300	5 600	10 500	23 800	897 100	Sheet
		-3	250	4 700	8 800	19 800	901 000	Sheet
		-2	200	3 700	7 000	15 900	2 188 600	Sheet
		-4	175	3 300	6 100	13 900	2 365 400	Sheet
		-7	175	3 300	6 100	13 900	2 804 700	Sheet
		-5	150	2 800	5 200	11 900	3 815 600	Sheet
		-9	135	2 500	4 700	10 700	5 561 800	Sheet
		-6	125	2 300	4 400	9 900	86 866 600	Sheet
		-10	120	2 200	4 200	9 500	49 852 200	Sheet
		-12	115	2 100	4 000	9 100	28 770 100	Sheet
Alclad 75S-T	0.066	63317-0	1270	23 800	44 400	101 000	Static Test	Rivet
		-10	550	10 300	19 200	43 600	144 900	Sheet
		-8	500	9 400	17 500	39 700	170 800	Sheet
		-7	400	7 500	14 000	31 700	318 500	Sheet
		-9	300	5 600	10 500	23 800	900 200	Sheet
		-2	200	3 700	7 000	15 900	4 267 200	Sheet
		-1	150	2 800	5 200	11 900	14 267 400	Sheet
		-6	135	2 500	4 700	10 700	103 987 300	None
		-3	125	2 300	4 400	9 900	16 668 000	Sheet
		-5	120	2 200	4 200	9 500	101 203 900	Sheet
		-4	110	2 100	3 800	8 700	103 745 600	None

Notes: (1) All specimens loaded across-grain.
(2) Four specimens loaded in each fatigue test; loads per rivet are average.
(3) Static shear strengths are average of three tests.
(4) Rivet shear stress based on hole area (diameter = 0.191 in.).
(5) Sheet stress based on net section through hole.
(6) Bearing stress based on hole diameter.

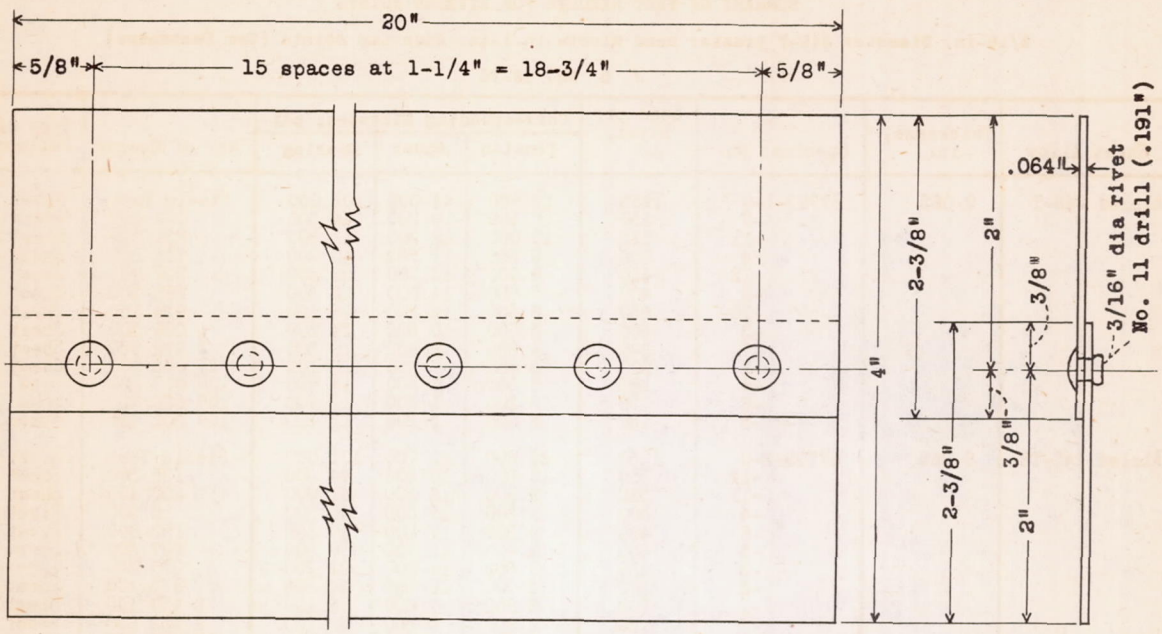

Figure 1.- Panel for fatigue tests of riveted joints.

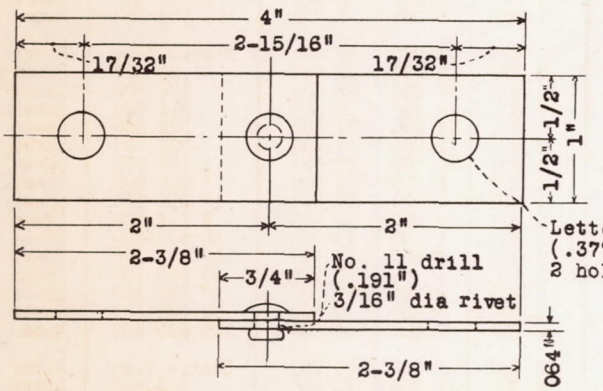

Figure 2.- Rotating beam fatigue machine specimen detail. Riveted specimen of 14 gage (.064") sheet.

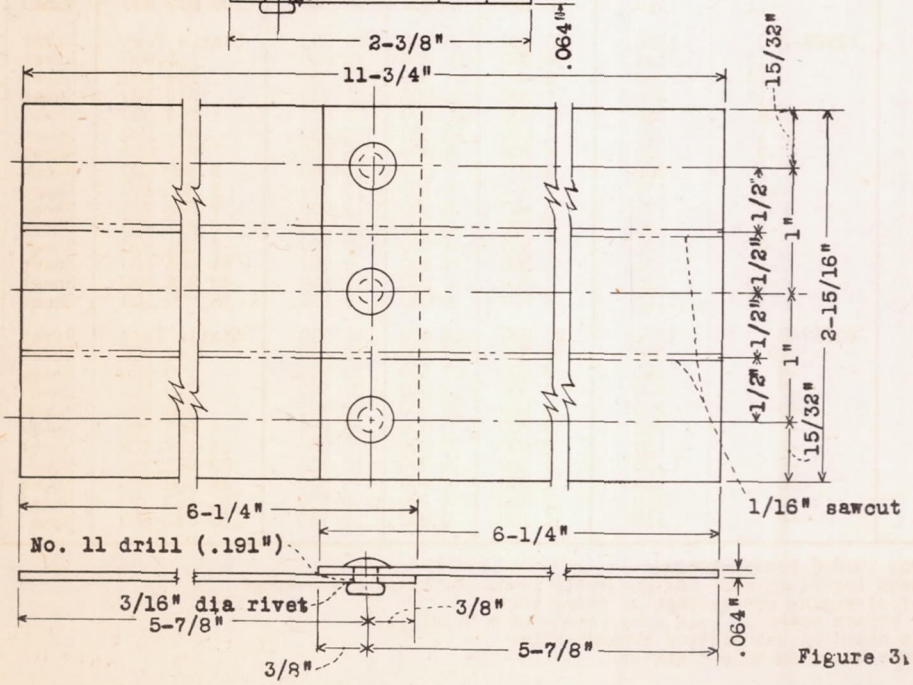

Figure 3.- Panel for static tests of riveted joints.

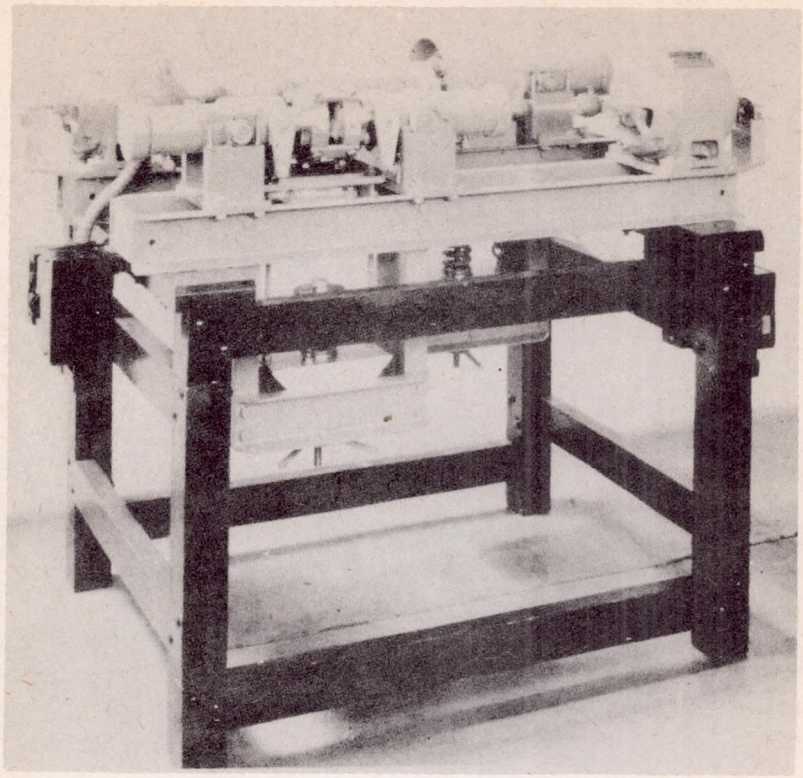

Figure 4.- Fatigue testing machines of rotating beam type designed and built at Aluminum Research Laboratories in 1942.

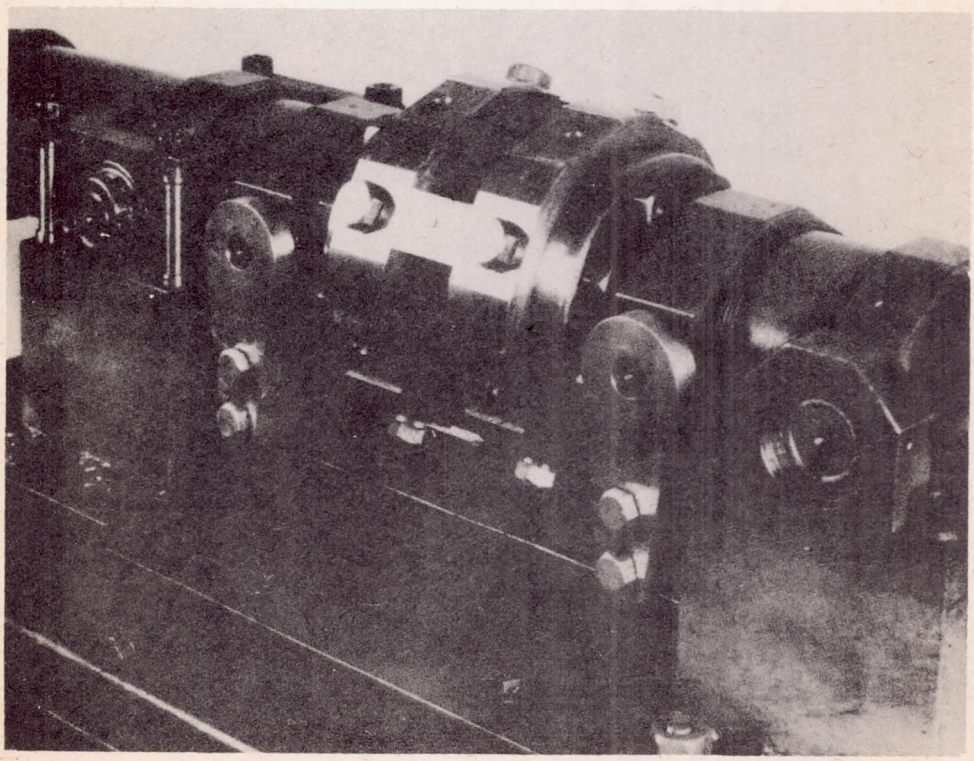

Figure 5.- Fixtures for loading riveted joints in fatigue testing machine.

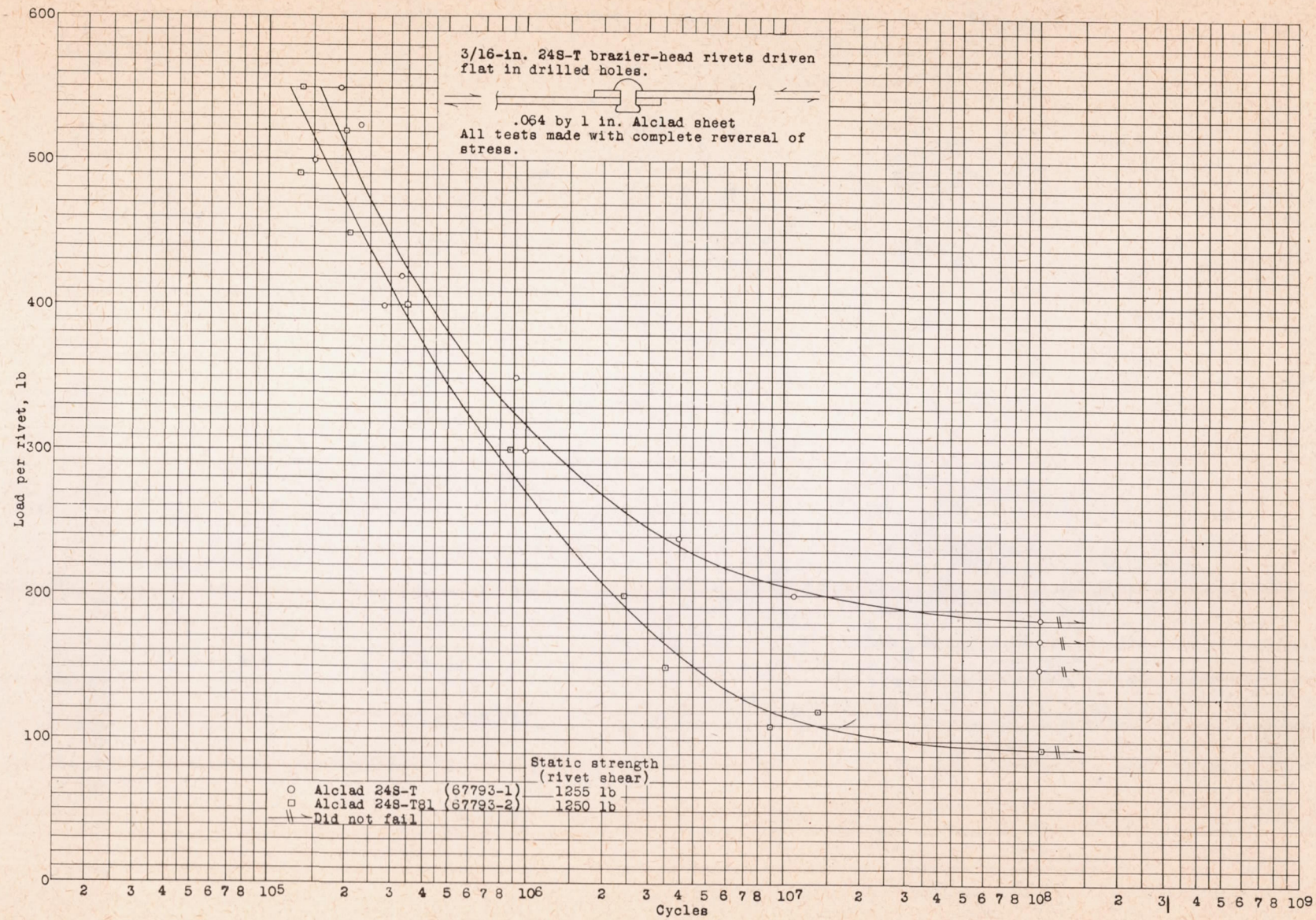

Figure 6.- Shear fatigue tests of riveted joints.

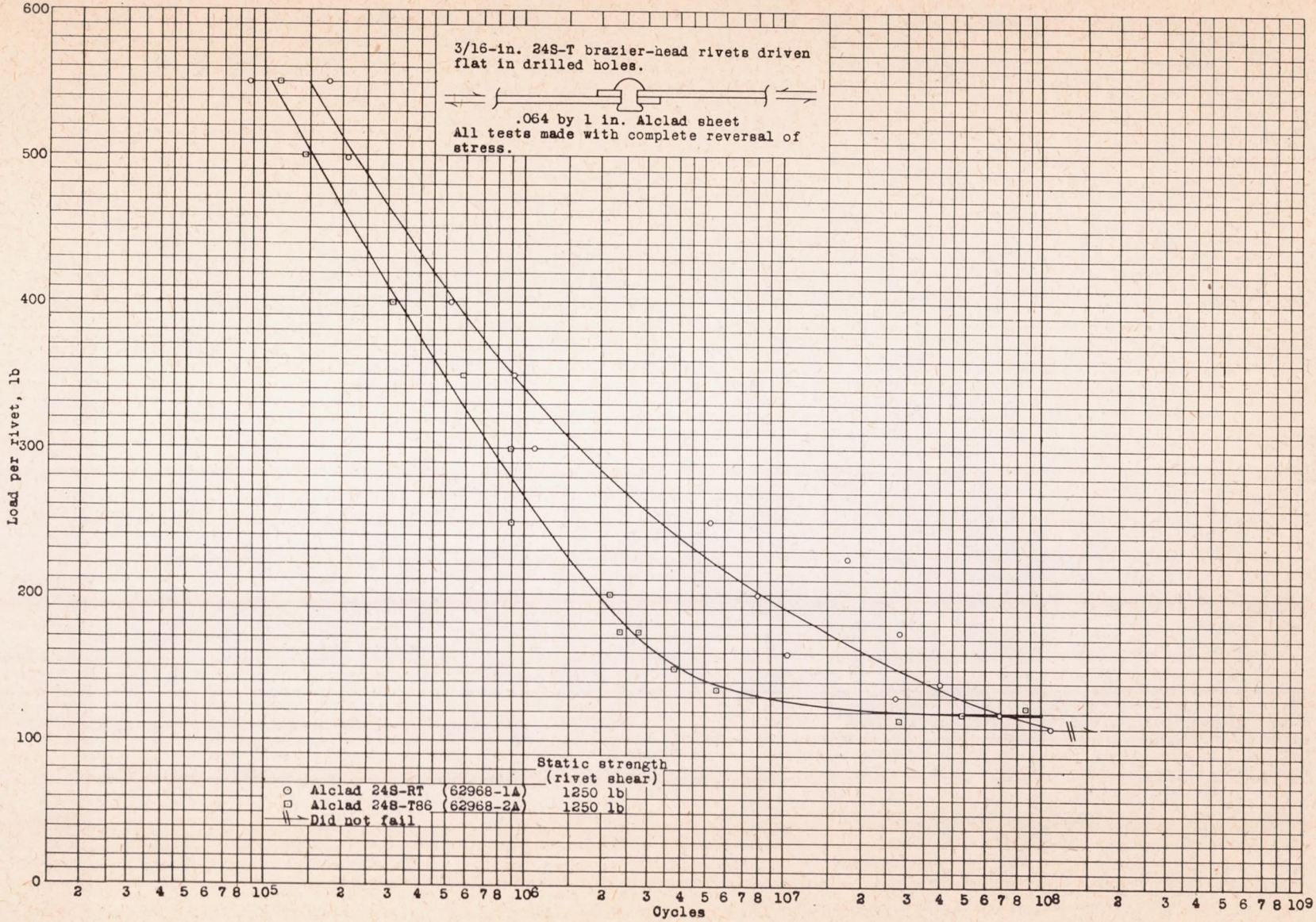

Figure 7.- Shear fatigue tests of riveted joints.

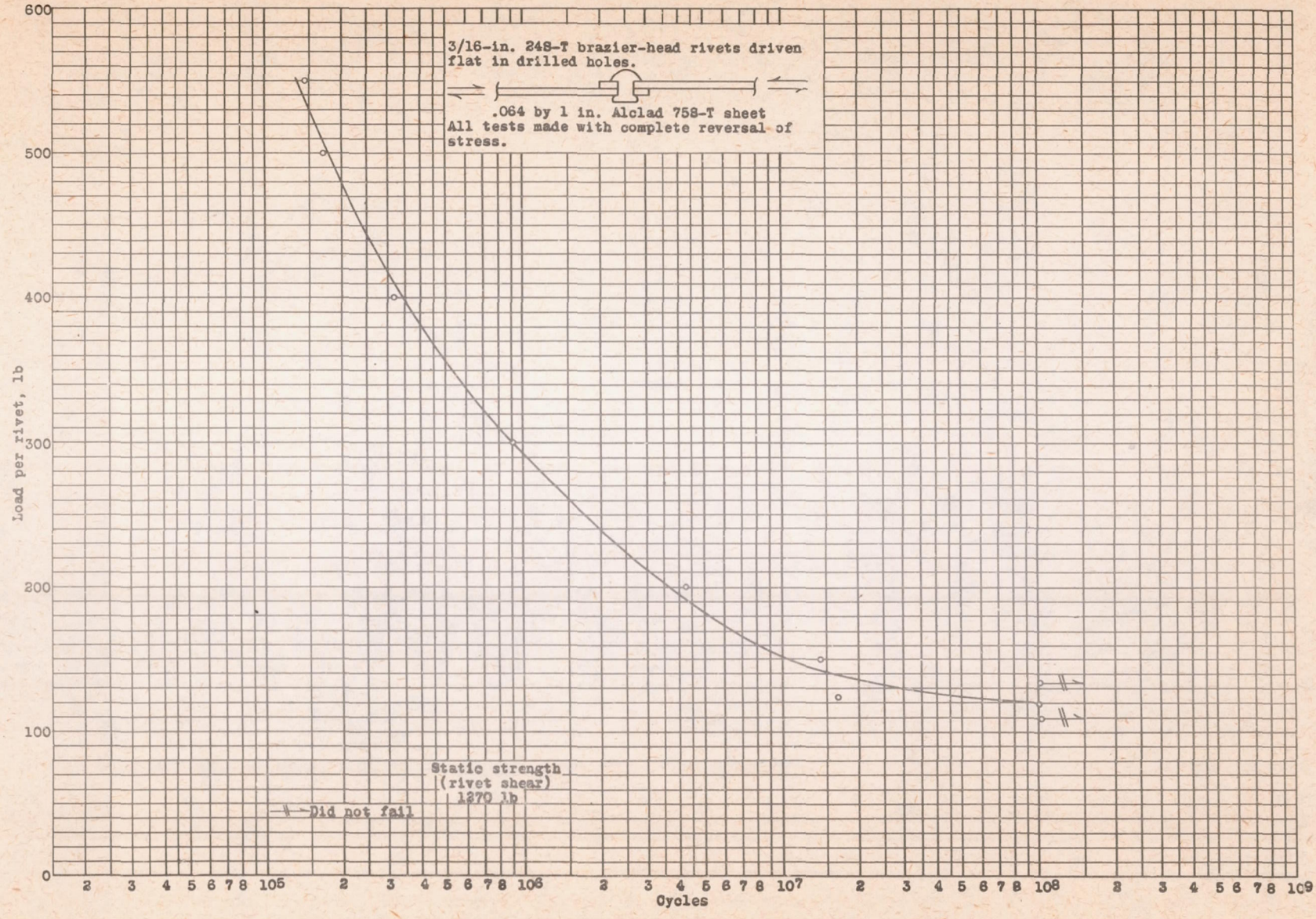

Figure 8.- Shear fatigue tests of riveted joints.

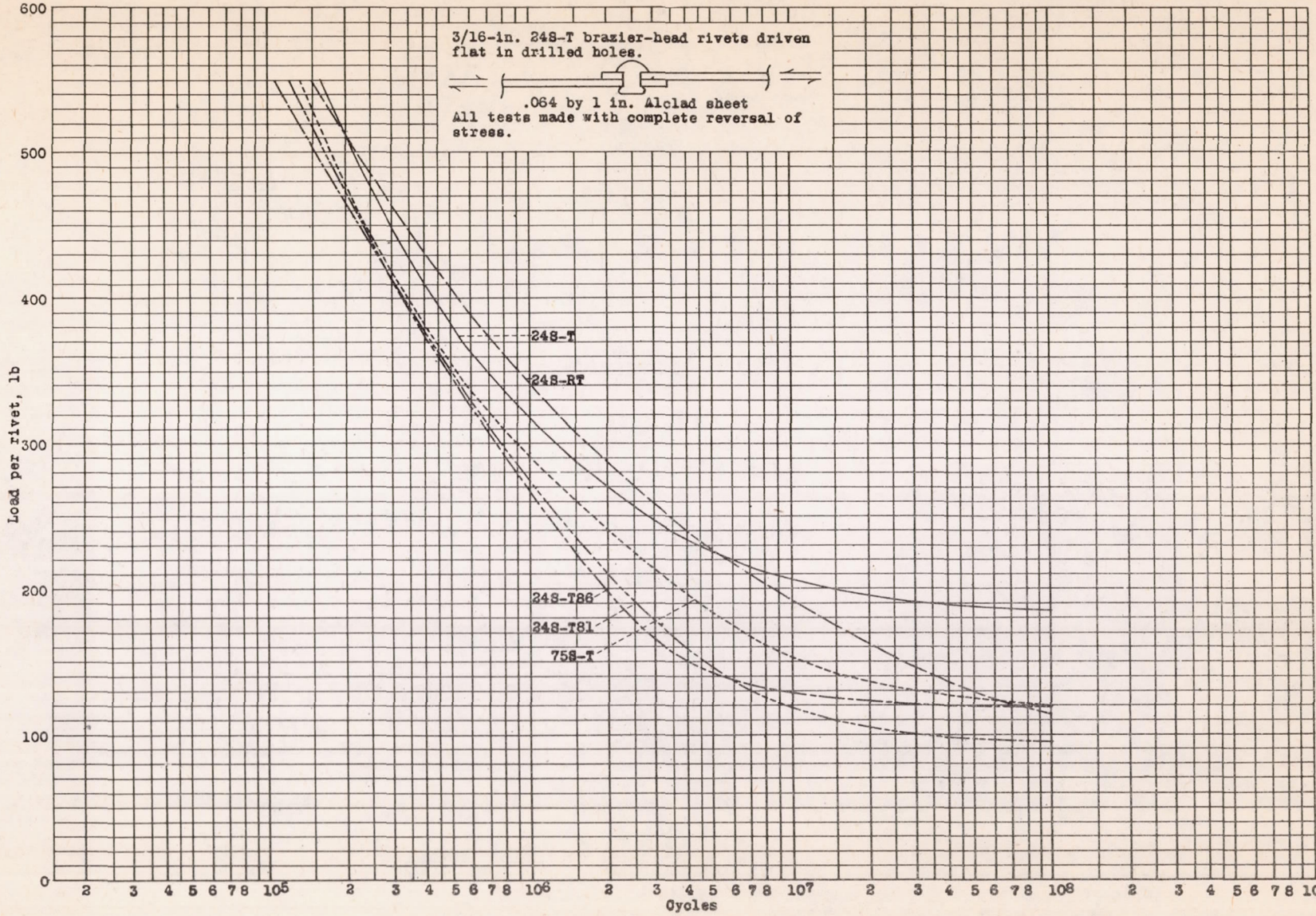

Figure 9.- Shear fatigue tests of riveted joints.